DESIGN AND IMPLEMENTATION OF 17 DOF HUMANOID ROBOT TO PERFORM VARIOUS HUMAN MOVEMENTS AND SURVEILLANCE

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ABSTRACT

The "Design and Implementation of a 17 DOF Humanoid Robot for Human Movements and Surveillance" project introduces a versatile humanoid robot that combines both entertainment and security functionalities. This innovative robot is equipped with 17 Degrees of Freedom (DOF), providing it with the flexibility to replicate various human movements and serve as a surveillance tool. The robot's hardware components include servo motors, a custom robot frame, an Arduino microcontroller, NodeMCU, and an ESP32cam module for surveillance capabilities. The ESP32cam allows for real-time video streaming and surveillance. It's designed to enhance security and can be remotely controlled to assist in providing visual feedback through live video feeds. The robot's additional function is to illuminate its surroundings by activating a flashlight, offering assistance in low-light situations. In the realm of human-like movements, the robot is capable of replicating a wide array of actions such as walking, waving, and more. This feature provides an entertaining element and highlights the robot's potential in interactive settings. Moreover, the inclusion of a Passive Infrared (PIR) sensor allows the robot to detect human presence and movement effectively. It can respond to human activity by transmitting alerts, making it suitable for surveillance in homes or offices, or to assist in various security-related applications. The "Design and Implementation of a 17 DOF Humanoid Robot for Human Movements and Surveillance" project merges the realms of robotics and security. By offering entertainment through human-like movements and enhancing security through surveillance capabilities, this project showcases the potential of humanoid robots to serve dual roles in various context. As technology advances, these robots could play a significant role in surveillance, entertainment, and assistance in both domestic and industrial setting.

I.INTRODUCTION

1.1 INTRODUCTION TO PROLOGUE

Robotics is a multidisciplinary field at the intersection of computer science, engineering, and mathematics, focusing on the design, construction, operation, and use of robots. Robots are automated machines that can perform tasks autonomously or semi-autonomously, often with some level of artificial intelligence.

At its core, robotics encompasses intricate mechanical design, where engineers meticulously craft the physical architecture and mechanisms that empower robots to navigate their surroundings and manipulate objects with precision and finesse. This involves delving into the intricacies of kinematics, which governs the motion of robotic limbs, as well as dynamics, which elucidates the forces and torques exerted during movement. Furthermore, an understanding of materials science is indispensable for selecting the optimal materials to ensure durability, flexibility, and efficiency in robot construction.

Moreover, the electronic circuitry and sensor arrays embedded within robots serve as their sensory organs, enabling them to perceive and interact with the environment. From high-resolution cameras and ultrasonic sensors to sophisticated lidar systems and gyroscopes, these sensory inputs provide robots with invaluable data to navigate complex terrains, detect obstacles, and identify objects of interest.

However, the true essence of robotics lies in its intricate control systems, orchestrating the symphony of motion and cognition that propels robots through their tasks. Through sophisticated algorithms for motion planning, pathfinding, and feedback control, engineers imbue robots with the agility and adaptability to traverse dynamic environments while avoiding collisions and optimizing energy consumption.

Programming serves as the linchpin of robotic functionality, endowing robots with the intelligence and autonomy to execute predefined tasks with precision and efficiency. Whether utilizing traditional programming languages like C/C++ or harnessing the power of specialized robotics frameworks such as ROS (Robot Operating System), programmers craft algorithms that dictate every facet of a robot's behavior, from simple movements to complex decision-making processes.

Furthermore, as the frontiers of robotics continue to expand, the integration of artificial intelligence and machine learning algorithms heralds a new era of cognitive robotics. By leveraging vast datasets and iterative learning processes, robots can adapt to unforeseen scenarios, refine their strategies through experience, and continually enhance their performance over time.

Ultimately, the applications of robotics span a diverse spectrum of industries and domains, from revolutionizing manufacturing processes and enhancing healthcare delivery to facilitating agricultural automation and advancing exploration in space and underwater realms. By harnessing the ingenuity and creativity of roboticists, these remarkable machines promise to reshape our world, ushering in an era of unprecedented innovation and possibility.

1.2 Objective of the project

Objective for stage-1:

The objective of stage 1 is to develop the 17 DOF humanoid Robot with servo motors and PCA controller that performs basic features like walking, exercise.

Objective of stage-2:

The objective of stage 2 is to develop the 17 DOF humanoid robot with ESP32cam to enhance security by providing real-time monitoring of an area and to transmit real-time video footage.

II. LITERATURE SURVEY

A literature survey on the design and implementation of 17 DOF humanoid robots would involve reviewing academic papers, conference proceedings, and relevant publications. Look for studies on mechanical design, control algorithms, sensor integration, and real-world applications of such robots. Consider sources from robotics conferences, journals, and reputable research institutions to gather insights into the state-of-the-art techniques, challenges, and advancements in this field.

Investigate how researchers have tackled challenges related to balance, agility, and coordination in these robots. Additionally, examine studies that showcase applications in areas such as human-robot interaction, healthcare, or industry. Summarize key findings and identify emerging trends to gain a comprehensive understanding of the current landscape in 17 DOF humanoid robot development.

ASIMO (Advanced Step in Innovative Mobility) is one of the greatest achievements by HONDA in the field of Humanoid robots. Honda started the development of this robot in the year 1980 and launched ASIMO in 2000. The name was chosen in honour of Isaac Asimov.The evolution of the robot from the beginning to till date can be seen in the figure.ASIMO has a height of 130cm and weighs about 54kg. It can recognize moving objects, surrounding environment, sounds, and faces. It can also understand the gestures and postures portrayed by others. The latest model of this robot achieved the ability to climb stairs and also to run which was a critical task of humanoid research. The recent advancements in the latest model includes the ability to walk, run, run backward, hop on single or two legs continuously. With the implementation of AI, it is capable of having a coordination between visual and auditory sensors to simultaneously recognize a face and voice of a person. It can also predict the walking direction of person in next few seconds and plan its locomotion accordingly to avoid collisions.

NAO was launched in the year 2004 by Aldebaran robotics, a French-based company under the Softbank group.This robot was initially developed for soccer competition at RoboCup Standard Platform League (SPL). NAO is widely used for research and educational purpose in educational institutions and research laboratories all over the globe. Nao was used to teach english to the students of age 3 and 4 whose native language is dutch Different versions of NAO come with 14, 21, and 25 Degrees of Freedom with a height of 22.6 in and 10.8-inch width.NAO is integrated with a wide range of sensors for its perfect balance and positioning within space. The advancements in the latest model includes the optimization of its hardware with stronger metal gears in joints, soles which help to dampen the noise and friction of footsteps. It also comes with the advanced features of shape and face detection with optimized algorithms with improved distance estimation. More powerful battery system is integrated which is 30% more efficient than the previous generation model. It is packed with a Linux based operating system platform which helps the researches to understand and further develop the robot.

III. HARDWARE DESCRIPTION

ARDUINO UNO

Arduino Uno R3 is one kind of ATmega328P based microcontroller board. It includes the whole thing required to hold up the microcontroller; just attach it to a PC with the help of a USB cable, and give the supply using an AC-DC adapter or a battery to get started. The term Uno means “one” in the language of “Italian” and was selected for marking the release of Arduino’s IDE 1.0 software. The R3 Arduino Uno is the 3rd as well as most recent modification of the Arduino Uno. Arduino board and IDE software are the reference versions of Arduino and currently progressed to new releases.

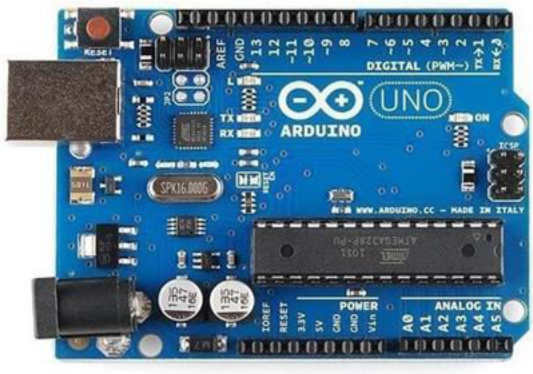

Fig1: Arduino UNO Board

SERVO MOTOR

The MG995 servo motor stands as a versatile and dependable component in the realm of hobbyist and DIY projects, renowned for its robust performance and affordability. Encased within its compact dimensions, typically around 40mm x 20mm x 40mm, lies a combination of plastic gearbox and aluminum casing, striking a balance between lightweight design and durability.

MG995 Servo Motor is a heavy-duty reliable servo motor. It is a low-power, cost-effective motor. MG995 is a dual shock-proof ball-bearing servo design with metal gear making it quite feasible for industrial production. The motor has a quick response and rotates at high speed. It comes with great holding power and a stable constant torque range. They are widely used in consumer robotics and hobby projects. This post is an overview of the motor and discusses the pinout, features, working, interfacing with Arduino, and applications of MG995.

Fig2: MG995 Servo Motor

LIGHT EMITTING DIODE

A light-emitting diode (LED) is a semiconductor device that emits light when an electric current flows through it. When current passes through an LED, the electrons recombine with holes emitting light in the process. LEDs allow the current to flow in the forward direction and blocks the current in the reverse direction.

Fig3: Light emitting diode

LITHIUM-ION-BATTERY

Lithium-ion is the rechargeable battery chemistry. Lithium-ion batteries power the devices we use every day, like our mobile phones and electric vehicles. Lithium-ion batteries.consist of single or multiple lithium-ion cells, along with a protective circuit board

Fig4: LI-ION Battery

IR REMOTE CONTROL

You've likely encountered the infrared remote controller, also known as the IR remote controller, while using home electronic devices like TVs and air conditioners... In this tutorial, we are going to learn how to use infrared (IR) remote controller and infrared receiver to control Arduino.The humble IR remote, that black baton of TV command, reigns supreme in living rooms worldwide. A button press becomes a whispered language of light, beamed from its LED tip to the watchful eye of your devices. This infrared orchestra conducts volume surges, channel pirouettes, and the cozy lull of the air conditioner's high.

Simple, reliable, and affordable, it's the maestro of a thousand gadgets. But like any good act, it has its limits. Walls can become sound barriers, range falters, and a cluttered coffee table can lead to remote-flinging frustration. Still, the future holds a harmony of possibilities.

Wi-Fi whispers, Bluetooth leaps, and the magic of voice might take center stage, but the IR remote, a timeless classic, will always hold a special place in the symphony of home electronics.

So next time you reach for that familiar black wand, remember, it's more than just a button pusher – it's a conductor of comfort, a silent ambassador of entertainment, and a reminder that even the simplest technology can orchestrate joy in our everyday lives.

The remote control emits pulses of infrared light, each representing a specific command or function, such as power on/off, volume adjustment, or channel selection. Upon receiving these signals, the device's infrared receiver decodes the transmitted data and executes the corresponding action.IR remotes often feature a range of buttons or keys, each assigned to a particular function, offering users convenient and intuitive control over their devices from a distance.

Fig5: IR Remote

ESP32 CAM

The ESP32-CAM is a small size, low power consumption camera module based on ESP32. It comes with an OV2640 camera and provides onboard TF card slot.The ESP32-CAM can be widely used in intelligent IoT applications such as wireless video monitoring, WiFi image upload, QR identification, and so on. It is suitable for home smart devices, industrial wireless control, wireless monitoring, and other IoT applications. ESP integrates WiFi, traditional Bluetooth, and BLE Beacon, with 2 high-performance 32-bit LX6 CPUs, 7-stage pipeline architecture. It has the main frequency adjustment range of 80MHz to 240MHz, onchip sensor, Hall sensor, temperature sensor, etc.

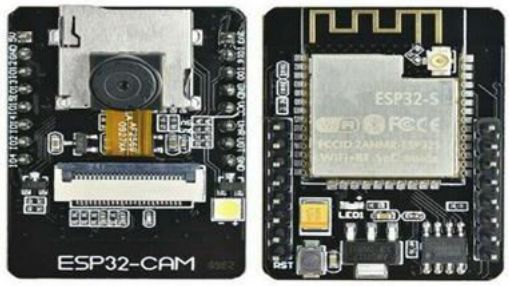

Fig6: ESP32

IV. PROPOSED SYSTEM

A humanoid robot with 17 degrees of freedom (DOF) would likely have a design that allows for a wide range of movements, mimicking human-like actions. Here's a breakdown of key components Such a system enables the robot to perform complex actions, including walking, grasping objects, and interacting with the environment in a more human-like manner. The control and coordination of these DOFs would involve sophisticated algorithms to ensure smooth and precise movements.

BLOCK DIAGRAM

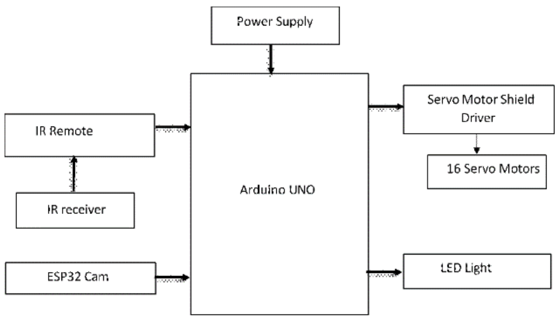

Fig7: Block Diagram

WORKING PRINCIPLE

A 17 Degrees of Freedom (DOF) robot, employing MG995 servos, an Arduino Uno microcontroller, and a PCA (Pulse Code Modulation) controller, operates through a collaborative synergy of hardware and software components. The MG995 servos act as the joints of the robot, allowing it to move with precision and flexibility across multiple axes. The Arduino Uno serves as the brain of the operation, receiving commands and sending signals to the servos based on programmed instructions. The PCA controller, also known as a servo driver, facilitates efficient control of multiple servos simultaneously by converting serial commands from the Arduino into PWM (Pulse Width Modulation) signals. These signals determine the position and speed of each servo, enabling coordinated motion of the robot's limbs and joints. Through this integrated system, the 17 DOF robot can perform complex movements and tasks, ranging from basic gestures to sophisticated maneuvers, making it suitable for various applications in robotics, education, and research.

SCHEMATIC DIAGRAM

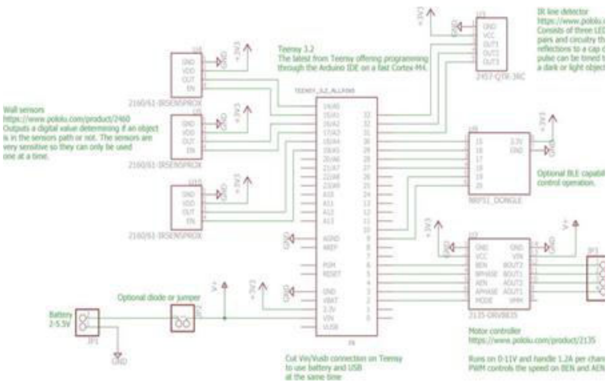

Fig8: Schematic diagram

17 robot joints, like elbows and knees. Map it Boxes for head, chest, arms, legs, connected by lines like wires. Arrows whisper data from robot's "eyes" and "ears" to its brain-like controller. Controller tells tiny motors in each joint what to do, like pulling strings. Different maps for different moves! One for walking, with leg joints clicking like gears. Another for picking up toys, with each finger a mini-dancer. Maps change for different robots, just like their dances. Many small maps, bigger picture of amazing robots. Lines and boxes unlock secrets of movement and a future where machines and humans dance as one.Each line and box holds the key to understanding, pushing the boundaries of what machines can do. See, these maps aren't just for robots, they're for curious minds like yours, unlocking the secrets of movement and the future were humans and machines dance together.

3.5 FLOW DIAGRAM

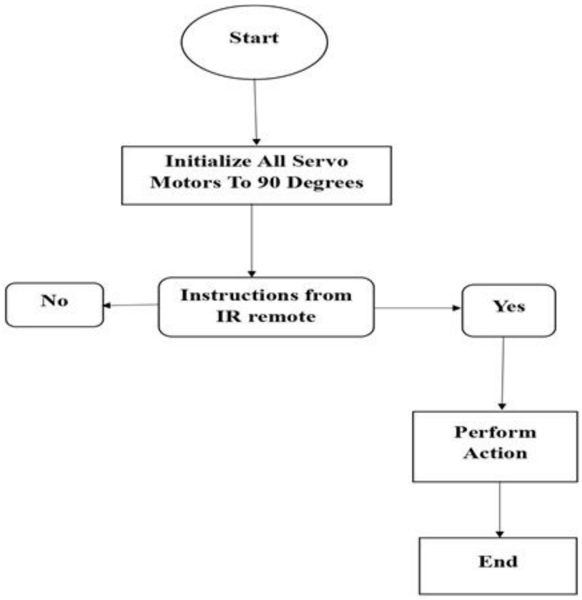

Fig9: Flow Diagram

V.RESULT

Stage-1 Result:

The Constructed humanoid robot achieved the desired goals of the project. The result indicated that robot could potentially achieve complex movements and tasks involve walking, exercise in a more human like manner. In which it can be controlled by IR remote controller.

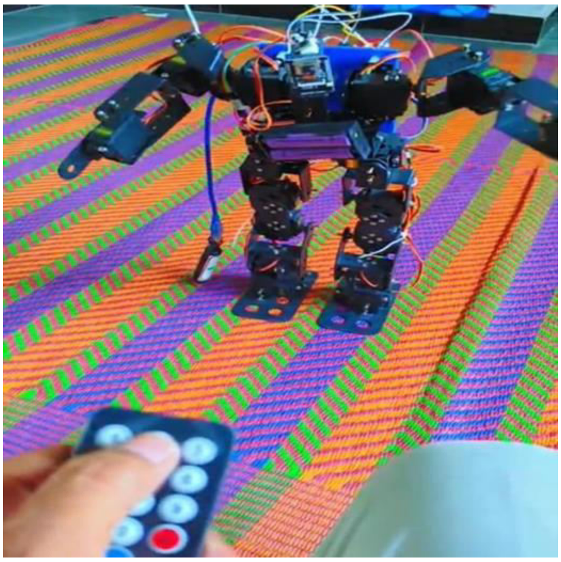

Fig10: stage-1 working model

Stage-2 result:

In the stage 2 module the robot chassis allows the device to move around and capture video in different locations. The system can be controlled through a web interface hosted on ESP32cam board.

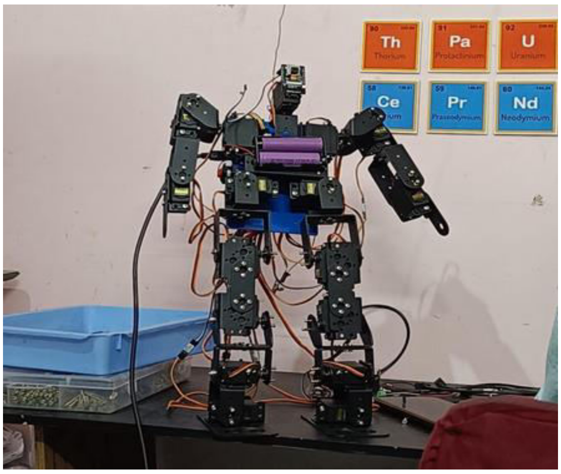

Fig11: stage-2 working model

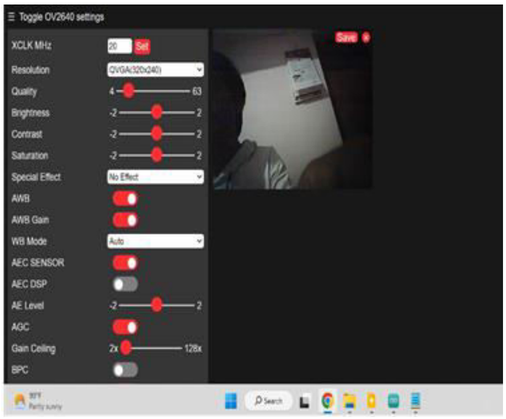

Fig12: Output

VI. APPLICATIONS

1. Research and Development:

Biomechanics Studies: The humanoid robot can be used in biomechanics research to study human movements, providing valuable insights into the mechanics of locomotion, balance, and coordination.

2. Healthcare:

Rehabilitation Assistance: The robot can assist in rehabilitation exercises for patients recovering from injuries or surgeries, providing personalized and controlled movements to aid recovery.

3. Education:

Robotics Education: The humanoid robot serves as an educational tool for teaching robotics, kinematics, dynamics, and control systems to students at various academic levels.

4. Entertainment:

Performing Arts: The robot can be employed in the entertainment industry for live performances, showcasing human-like movements in theatres or events.

5. Human-Machine Interaction:

Assistive Devices: The robot can be integrated into assistive devices to help individuals with limited mobility in performing daily tasks.

VII. ADVANTAGES

1. Human-Like Movements:

The 17 DOF design allows the humanoid robot to mimic a wide range of human movements with a high degree of precision and fluidity, making it suitable for applications that require natural and lifelike motions.

2. Versatility in Tasks:

The multiple degrees of freedom enable the robot to perform a diverse set of tasks, from simple activities to complex movements, making it adaptable to various environments and applications.

3. Research and Development:

In research settings, the humanoid robot can be used to study human biomechanics and behaviour, providing valuable insights for fields such as robotics, artificial intelligence, and neuroscience.

4. Rehabilitation Assistance:

In healthcare, the robot can assist in rehabilitation exercises, offering personalized and controlled movements to aid patients recovering from injuries or surgeries.

5. Educational Tool:

The humanoid robot serves as an effective educational tool, allowing students to learn about robotics, kinematics, dynamics, and control systems through hands-on experience with a sophisticated system.

6. Entertainment and Performing Arts:

In the entertainment industry, the robot can be employed for live performances, creating engaging and captivating shows that leverage its ability to replicate human movements.

XIII.CONCLUSION

In conclusion, the design and implementation of a 17 Degree of Freedom (DOF) humanoid robot for mimicking various human movements represent a significant achievement in the field of robotics. The intricate combination of mechanical, electronic, and programming elements has resulted in a versatile and dynamic robotic system capable of emulating a wide range of human motions. The successful integration of sensors, actuators, and control algorithms has enabled the humanoid robot to exhibit fluid and lifelike movements, enhancing its ability to interact with the environment in a manner that closely resembles human actions. The comprehensive design process involved careful consideration of biomechanics, kinematics, and ergonomics, ensuring that the robot's motions are both natural and efficient.

Furthermore, the implementation of advanced control strategies, such as inverse kinematics and feedback mechanisms, has played a pivotal role in achieving precise and coordinated movements. These control techniques contribute to the robot's adaptability in responding to external stimuli, making it well-suited for a variety of applications, including assistance in healthcare, entertainment, and research.

FUTURE SCOPE

The design and successful implementation of a 17 Degree of Freedom (DOF) humanoid robot capable of replicating diverse human movements mark a significant achievement in robotics. As we look towards the future, there are exciting prospects for further advancementsin this field. The next steps involve exploring avenues such as enhanced sensor integration for improved environmental perception, the integration of artificial intelligence and machine learning to enable adaptive learning, and a focus on human-robot collaboration to ensure safe and productive interactions. Additionally, miniaturization and portability, along with a shift towards real-world applications in healthcare, disaster response, and hazardous environments, will be pivotal for expanding the practical utility of humanoid robots. Prioritizing energy efficiency, autonomy, and user interface enhancements will further contribute to the seam less integration of these robots into our daily lives. The future holds immense potential for refining and expanding upon the capabilities of humanoid robots, fostering a new era of innovation and collaboration at the intersection of robotics and human interaction.

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